Powertech
A subsidiary of BC Hydro

Powertech Labs Inc.
12388 - 88th Avenue
Surrey, British Columbia
Canada V3W 7R7

Tel: (604)590-7500
Fax: (604)590-5347
www.powertech.bc.ca

CONTROLLER OSCILLATORY AND FAST TRANSIENT SWC TEST REPORT

Client:	Schweitzer Engineering Laboratories Inc., 2440 NE Hopkins Court, Pullman, WA, 99163 USA		
Test Date:	October 15th ,2015	**Project:**	PL-27147

Nameplate Data:

Recloser Controller:

Manufacturer:	Schweitzer Engineering Laboratories, Inc.
Model:	SEL-651RA
Part No:	0651RA01XGAXAA1A111XBXXX
Serial No.:	1152650818

Three-phase Recloser:

Manufacturer:	G & W Electric Company
Type:	Viper-S
Impulse level (BIL):	150 kV_{peak}
Rated voltage:	38 kV_{rms}
Rated current:	800 A_{rms} continuous
Serial No.:	2015-0821-0002

Test Standard:	IEEE C37.60-2012, Clause 6.111.2: "Oscillatory and fast transients surge tests"
Test Witness:	Mark Feltis – Schweitzer Engineering Laboratories Inc.,
Atmospheric Conditions:	Temperature 22.5 °C Relative humidity 57.7 % Barometric pressure 753.5 mmHg
Test Voltage:	Oscillatory - 2.5 kV_{peak} , Fast Transient – 4 kV_{peak}
Test Procedure:	The testing was in accordance with IEEE C37.90.1-2012. Test surges were applied to the control cable in common and transverse mode using an external coupling/decoupling network in accordance with Table 3 and 4 of IEEE C37.90.1. Signal and data circuits were tested using a capacitive clamp. The AC power supply was tested while connected to 120 Volts, 60 Hz supply for all tests.
Test Results:	The controller and recloser operated normally following the Oscillatory and Fast Transient Tests performed in accordance with the test procedures as per the above document. The controller complied with requirements of "IEEE C37.60-2012, Clause 6.111.2".
Remarks:	Viper-S voltage sensor board was modified prior to equipment successfully passing the test.

Tested by:

Hamish Miller, EIT.
Test Engineer, High Voltage Laboratory

Reviewed by:

Nov. 17, 2015
Alex Babakov, P. Eng.
Test Engineer, High Voltage Laboratory

Fast Transient Waveform Validity Tests

(in accordance with IEEE Std C37.90.1-2012, Clause B.2)

Performed before the Fast Transient Test

1. Measuring system feed through test

   Generator Output voltage 4 kV

   Feed through voltage 2.1 V (pass if ≤ 1%)

2. Open circuit voltage waveform test

   Recorded waveforms – Figures 1 and 2.

3. Test Generator performance verification

Test duration	60.0	s	(≥ 60 s)
Burst period	293.6	ms	(240 to360 ms)
Burst duration	14.9	ms	(12 to 18 ms)
Repetition rate	2.5	kHz	(2 to 3 kHz)
Impulse duration	62	ns	(35 to 65 ns to 50% value)
Rise time	5.6	ns	(3.5 to 6.5 ns – 10% to 90%)
Peak voltage level (no load)	4.20	kV	(3.6 to 4.4 kV when set to 4 kV)
Output impedance	40.6	Ω	(40 to 60 Ω)

4. Test Pass X Test Fail _____

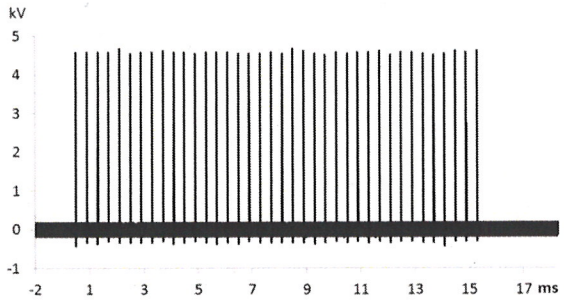

Figure 1

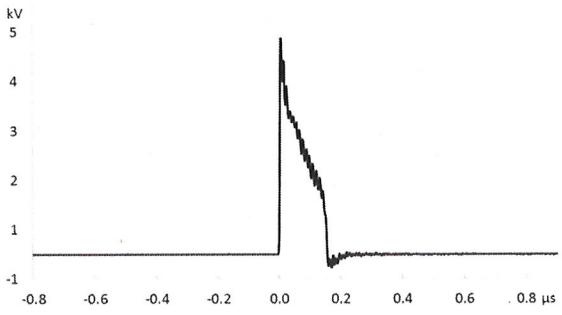

Figure 2

Fast Transient Waveform Validity Tests

(in accordance with IEEE Std C37.90.1-2012, Clause B.2)

Performed after the Fast Transient Test

1. Measuring system feed through test

   Generator Output voltage 4 kV

   Feed through voltage 11.6 V (pass if ≤ 1%)

2. Open circuit voltage waveform test

   Recorded waveforms – Figures 1 and 2.

3. Test Generator performance verification

Test duration	60.0	s	(≥ 60 s)
Burst period	282.2	ms	(240 to360 ms)
Burst duration	14.8	ms	(12 to 18 ms)
Repetition rate	2.6	kHz	(2 to 3 kHz)
Impulse duration	35.3	ns	(35 to 65 ns to 50% value)
Rise time	5.4	ns	(3.5 to 6.5 ns – 10% to 90%)
Peak voltage level (no load)	4.18	kV	(3.6 to 4.4 kV when set to 4 kV)
Output impedance	49.5	Ω	(40 to 60 Ω)

4. Test Pass X Test Fail _____

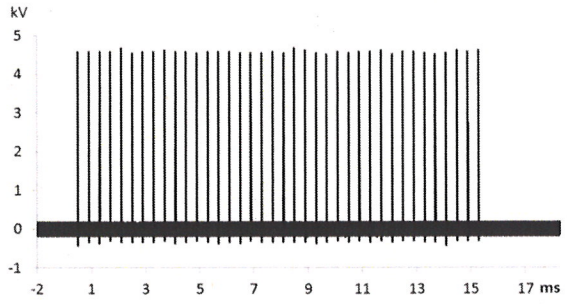

Figure 1

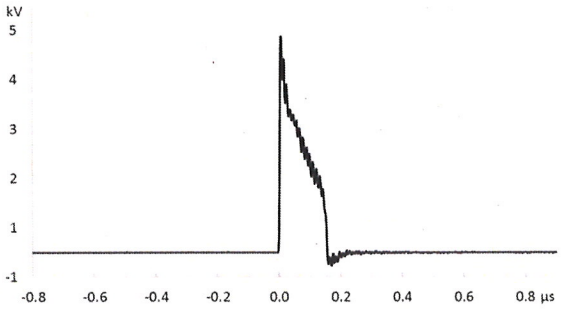

Figure 2

Oscillatory Waveform Validity Tests

(in accordance with IEEE Std C37.90.1-2012, Clause B.2)

Performed before the Oscillatory SWC Test

1. Measuring system feed through test

   Generator Output voltage 2.5 kV

   Feed through voltage 9.4 V (pass ≤ 1%)

2. Open circuit voltage waveform test

   Recorded waveforms – Figures 1 and 2.

3. Test Generator performance verification

Test duration	2.1	s	(2 to 2.2 s)
Repetition rate	8	bursts per period	(6-10 bursts per 16.7 ms)
Oscillation frequency	0.91	MHz	(0.9 to 1.1 MHz)
Waveform envelope decay	5.1	µs	(4 to 6 µs to 50%)
Rise time of the first peak	80	ns	(60 to 90 ns – 10% to 90%)
Peak voltage level (no load)	2.25	kV	(2.25 to 2.5 kV when set to 2.5 kV)
Output impedance	184	Ω	(160 to 240 Ω)

4. Test Pass X Test Fail _____

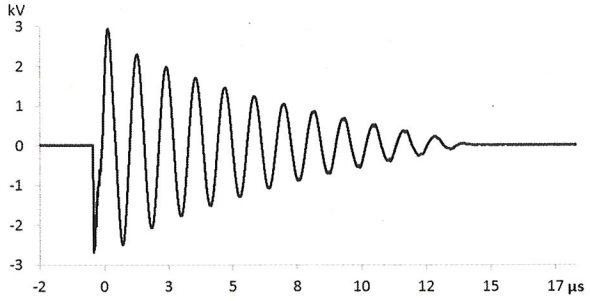

Figure 1

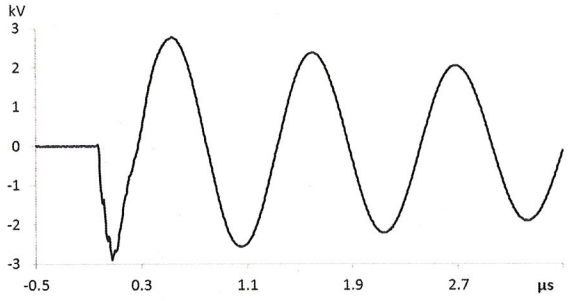

Figure 2

Oscillatory Waveform Validity Tests

(in accordance with IEEE Std C37.90.1-2012, Clause B.2)

Performed after the Oscillatory SWC Test

1. Measuring system feed through test

   Generator Output voltage 2.5 kV

   Feed through voltage 14.7 V (pass ≤ 1%)

2. Open circuit voltage waveform test

   Recorded waveforms – Figures 1 and 2.

3. Test Generator performance verification

Test duration	2.1	s	(2 to 2.2 s)
Repetition rate	9	bursts per period	(6-10 bursts per 16.7 ms)
Oscillation frequency	0.90	MHz	(0.9 to 1.1 MHz)
Waveform envelope decay	5.8	µs	(4 to 6 µs to 50%)
Rise time of the first peak	90	ns	(60 to 90 ns – 10% to 90%)
Peak voltage level (no load)	2.41	kV	(2.25 to 2.5 kV when set to 2.5 kV)
Output impedance	161	Ω	(160 to 240 Ω)

4. Test Pass X Test Fail _____

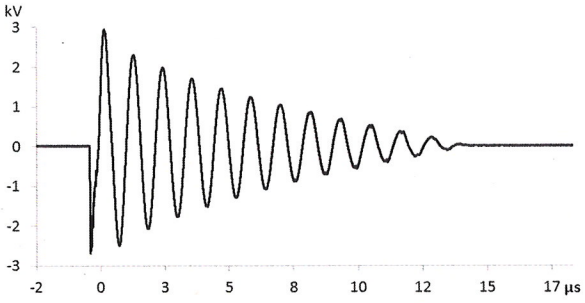

Figure 1

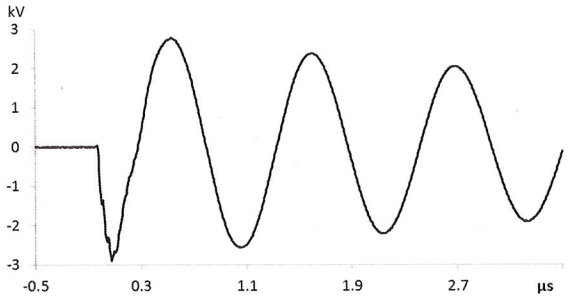

Figure 2

Powertech
A subsidiary of BC Hydro

Powertech Labs Inc.
12388 - 88th Avenue
Surrey, British Columbia
Canada V3W 7R7

Tel: (604)590-7500
Fax: (604)590-5347
www.powertech.bc.ca

RECLOSER-CONTROLLER SIMULATED SURGE ARRESTER OPERATION TEST REPORT

Client:	Schweitzer Engineering Laboratories Inc., 2440 NE Hopkins Court, Pullman, WA, 99163 USA		
Test Date:	October 15th & 16th,2015	**Project:**	PL-27147

Nameplate Data:

Recloser Controller:

Manufacturer:	Schweitzer Engineering Laboratories, Inc.
Model:	SEL-651RA
Part No:	0651RA01XGAXAA1A111XBXXX
Serial No.:	1152650818

Three-phase Recloser:

Manufacturer:	G & W Electric Company
Type:	Viper-S
Impulse level (BIL):	150 kV_{peak}
Rated voltage:	38 kV_{rms}
Rated current:	800 A_{rms} continuous
Serial No.:	2015-0821-0002

Test Standard: IEEE Std C37.60-2012, Clause 6.111.3: "Simulated Surge Arrester Operation Test"

Test Witness: Mark Feltis – Schweitzer Engineering Laboratories Inc.,

Atmospheric Conditions:

	October 15th, 2015	October 16th, 2015
Temperature	22.5 °C	19.5 °C
Relative humidity	57.7 %	45.3 %
Barometric pressure	753.5 mmHg	750.0 mmHg

Nominal Test Voltage and Current: 120 kV_{peak} (150 kV_{peak} * 0.8), 6.0 kA_{peak}

Test Configurations Tested (in accordance with the above standard)**:**

1 – 15 surges of positive polarity and 15 surges of negative polarity were applied to the source bushing with the recloser open.
2 – 15 surges of positive polarity and 15 surges of negative polarity were applied to the source bushing with the recloser closed.
3 – 15 surges of positive polarity and 15 surges of negative polarity were applied to the load bushing with the recloser closed.
4 - 15 surges of positive polarity and 15 surges of negative polarity were applied to a properly rated transformer with the recloser open.
5 - 15 surges of positive polarity and 15 surges of negative polarity were applied to a properly rated transformer with the recloser closed.

Test Results: The controller and recloser complied with the requirements of IEEE Std C37.60-2012, Clause 6.111.3, Configurations 1 -5.

Remarks: Viper-S voltage sensor board was modified prior to equipment successfully passing the test.

Tested by:

Hamish Miller, EIT.
Test Engineer, High Voltage Laboratory

Reviewed by:

Nov. 17 2015

Alex Babakov, P. Eng.
Test Engineer, High Voltage Laboratory